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# Incidence of Decompression Illness and Other Diving Related Medical Problems Amongst Royal Navy Divers 1995 – 1999

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## ABSTRACT

**Background:** The Diving Accident Database held at the Institute of Naval Medicine (INM) contains details of all Royal Navy, and the majority of UK recreational diving accidents, that have occurred since 1990. Details of all Royal Navy dives completed since 1995 are recorded on the Dive Database, also held at INM.

**Aim:** To determine the incidence of decompression illness (DCI), and other diving related medical incidents, amongst Royal Navy divers.

**Methods:** The number and type of dives completed by Royal Navy divers (including Ships Divers, Mine Clearance and Special Forces divers) between 1995 and 1999 was extracted from the Dive Database. Details of all cases of DCI, and other medical incidents, were extracted from the Diving Accident Database. The data was analysed and incident rates calculated for DCI and other medical conditions.

**Results:** During the 5 year period 106,487 dives were completed. 21 cases of DCI occurred (18.8/100,000) and 8 cases of pulmonary barotrauma (7.5/100,000). The incident rate for DCI following military air dives was 16/100,000, nitrox dives 19.4/100,000 and heliox dives (1.3 bar constant pO<sub>2</sub>) 58.4/100,000. The incident rate for DCI amongst recreational divers using air was estimated at 7.58/100,000.

**Discussion:** The incidence of DCI following military air dives is approximately twice that of DCI amongst the recreational diving community. However, there is believed to be significant underreporting of recreational DCI. The incidence of DCI following heliox dives is much greater than that associated with air dives. This increased incidence of DCI is probably a factor of depth and increasing decompression stress rather than that of difference in gas mix.

## BACKGROUND

The Institute of Naval Medicine holds paper records of most, if not all, Royal Navy diving accidents that have occurred since the early 1940's. Some of the earliest records relate to 'incidents' which occurred during Professor Donald's historic research into oxygen toxicity. Details of all dives are recorded in both the divers personal dive log and unit master dive log. Because of the large number of paper records analysis of the data contained within them would be difficult if not impossible. To assist in future analysis of data, and also to collect information as to the epidemiology and natural history of the decompression disorders, a computer database was developed at the Institute of Naval Medicine (INM) in 1990. This database was designed to record detailed information on all Royal Navy diving accidents, and with the assistance of the British Hyperbaric Association (BHA) all civilian cases of decompression illness treated by member chambers. As the BHA represents all of the major therapeutic recompression facilities in the UK it is estimated that over 80% of all civilian cases of decompression illness treated within the UK are recorded upon this database.

Details of numbers of accidents are of limited use without information as to the number, and type, of dives completed. To enable this information to become accessible in 1994 a second computer database was developed at INM to record details of all Royal Navy dives. The year 1994 was used to trial the reporting system and to ensure that all diving units were aware of the requirement to report their diving activities to INM. Data from the year 1994 is thus incomplete, with 1995 being the first complete data year. By combining the data from these two databases it has been possible to perform detailed analysis of both number and type of dives carried out as well as the incident rates for medical incidents including decompression illness.

During the period of the study there have been major changes in the type of diving apparatus used with the semiclosed Diving Set Self Contained Clearance Diving (DSSCCD) being replaced by the closed circuit Clearance Diving Breathing Apparatus (CDBA). DSSCCD used oxygen in nitrogen breathing mixtures and had a maximum operating depth of 54 metres whereas CDBA is used with oxygen in helium breathing mixtures and supplies the diver with a constant partial pressure of oxygen (1.3bar) down to a maximum depth of 80 metres. The closed circuit Long Endurance Breathing Apparatus (Mixed Gas) (LEBA (MG)) diving apparatus, which uses oxygen in nitrogen breathing mixtures, was also

introduced during the later part of the study period. LEBA(MG) permits diving to a maximum depth of 24 metres and supplies the diver with a constant partial pressure of oxygen (1.4bar).

## AIM

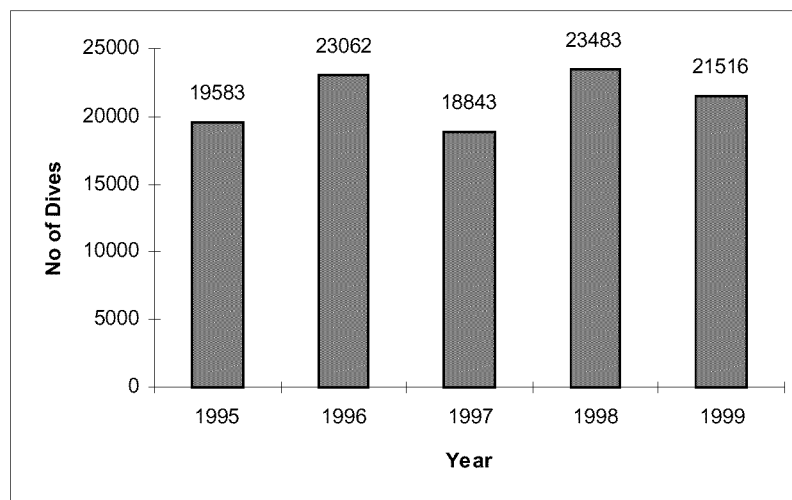
To determine the incidence of decompression illness, and other diving related medical incidents, amongst Royal Navy divers.

## METHODS

For the 5 years between 1995 to 1999 the number and type of dives completed by Royal Navy divers (including Ships Divers, Mine Clearance and Special Forces divers) was extracted from the Dive Database. Details of all cases of DCI, and other dive related medical problems, were extracted from the Diving Accident Database. Incident rates for DCI were calculated as were incident rates for other dive related medical conditions. Because the Diving Accident Database also contains details of recreational diving accidents, but not number of recreational dives, it has been possible to estimate incident rates amongst UK recreational divers and so make comparison with comparable military dives.

## RESULTS

During the 5 year period 1995-99 a total of 106,487 dives were completed by Royal Navy divers, an average annual total of approximately 21,297 dives. The majority of these dives, 74,677 (70%), used air as the breathing gas although with the introduction of CDBA the number of dives using heliox has increased from 104 (0.5%) in 1995 to 3227 (15%) of all dives in 1999. Analysis of the depth range of dives reveals that the majority of dives (65%) are shallow dives to depths between 0 and 11 metres with only 4,379 (4.1%) of dives exceeding a depth of 44 metres.



**Figure 1: Number of dives per year 1995-1999**

Moving to incidents, during the 5 year period there have been 20 cases of DCI. This does not include a case of arterial gas embolism that resulted from a diver accidentally opening the by-pass of the DSSCCD he was using when exiting the water.

The overall incident rate for decompression illness is thus 18.8/100,000 dives. More detailed analysis of the 20 cases of DCI reveals that 5 occurred following dives in the range 0-11 msw (7.1/100,000), 4 in the 12-24 msw depth range (16.5/100,000), 4 in the 25-43 msw depth range (50.6/100,000), 6 in the 44-69 msw depth range (137/100,000) and 1 following a dive deeper than 70 msw (621/100,000). Looking in detail at the dives to depths in excess of 44 msw, 2 cases of decompression illness were reported following air dives (147/100,000) with the remaining 5 occurring after heliox dives (351/100,000). Of the 5 cases of decompression after heliox dives 2 occurred following dives using surface supplied open circuit 20% oxygen in helium (855/100,000) with 3 cases occurring after 60 msw dives of short duration using CDBA (252/100,000).

**Table 1: Number of Diving Incidents and Incident Rate 1995-1999**

<b>Incident type</b>	<b>N</b>	<b>Incident rate/100,000</b>
Decompression illness	20	18.8
Pulmonary barotrauma	8	7.5
Oxygen toxicity	4	3.8
Hypoxia	4	3.8
Hypercapnia	1	0.9
Omitted decompression	2	1.9
Near Drowning	3	2.8
Inner ear barotrauma	1	0.9
Fatality	2	1.9
<b>Total</b>	<b>45</b>	<b>42.3</b>

In addition to the 20 cases of decompression illness there were also 8 cases of pulmonary barotrauma, incident rate 7.5/100,000. Four cases of hypoxia and 4 cases of oxygen toxicity were reported with an incident rate of 3.8/100,000 per condition. However, as both hypoxia and oxygen toxicity are primarily associated with rebreather use if only dives using rebreathers are considered the incident rate increases to 19.2/100,000.

Two fatalities occurred during the study period giving a fatality rate of 1.9/100,000 dives.

Between 1995 and 1999 BHA recompression chambers treated 758 recreational divers with DCI. It is estimated that the approximately 80,000 recreational divers in the UK complete an average of 25 dives per diver per year. This gives a figure of 2,000,000 dives per year. Using this estimated figure the incident rate for DCI amongst UK recreational divers is estimated at 7.58/100,000.

## DISCUSSION

Depth of dive appears to be associated with an increased incidence of decompression illness with an incident rate of only 7.1/100,000 for dives between 0-11 msw increasing to 137/100,000 for dives in the 44-69msw range. For dives to depths in excess of 44msw the incident rate for dives using air (147/100,000) is lower than that for dives using heliox (352/100,000). However, the maximum permitted depth for military air dives is only 50msw compared to the 80msw for heliox dives and as such direct comparison of risk can not be made. Indeed once the small number of dives (n=234) to depths in excess of 44msw using surface supplied open circuit 20% oxygen in helium, which accounted for 2 cases of decompression illness, are excluded the incident rate for decompression illness associated with deep (in excess of 44msw) dives using constant partial pressure 1.3 bar oxygen in helium falls to 252/100,000. Furthermore, all 3 cases of decompression illness associated with constant partial pressure 1.3 bar oxygen in helium have occurred following the same short duration (6 minute bottom time) 60msw dive profile. A possible explanation for this small cluster of cases following this particular dive profile is that divers are descending at a greater rate than called for by the table. With such a short duration dive even an extra 20-30 seconds actually spent at depth would be sufficient to change a 'safe' profile to one with an increased risk of decompression illness. The new 1.3 bar oxygen in helium tables, currently under evaluation, have been calculated with a faster descent rate to allow a margin of error if the diver should exceed the standard descent rate.

The incident rate for DCI at 7.58/100,000 for recreational divers appears to be less than half that for military divers at 18.8/100,000. However, almost all of the recreational dives will be carried out using air. Once all heliox and nitrox dives are excluded from the military figures then the incident rate for decompression illness following military air dives drops slightly to 16/100,000. Furthermore, the figure of 7.58/100,000 for recreational DCI is almost certainly an under estimate as it is known that not all chambers report cases to the Diving Accident Database. In addition to this underreporting from chambers there is also the fact that denial of symptoms and self-treatment with normobaric oxygen is not uncommon amongst recreational divers. The true figure for recreational divers may thus be some 20-50% greater than that estimated.

As well as decompression illness other significant diving related incidents have occurred during the study period, in particular 8 cases of pulmonary barotrauma confirmed by clinical examination and X-ray. All of these cases occurred after shallow dives, primarily training dives. In addition to the 8 cases of pulmonary barotrauma with no neurological deficit there were 5 cases of neurological decompression illness following shallow dives (0-11msw). Although there was no radiological confirmation of lung rupture in any of these 5 cases, lung rupture and arterial gas embolism is the most probable mechanism of causation, the depth time profiles of the incident dives being such that inert gas release on

decompression is considered highly improbable. These incidents illustrate the potential dangers associated with shallow water diving in which only small depth transitions, either due to poor buoyancy control or swell, can result in large and damaging pressure changes.

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